DEMONSTRATION OF TRANSPIRING WALL SCWO TECHNOLOGY FOR CHEMICAL WEAPONS DESTRUCTION AT BLUE GRASS

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Foster Wheeler and GenCorp Aerojet have developed a unique SCWO reactor/liner system that protects the liner and the reactor pressure boundary against corrosion and salt deposition. The design uses a porous liner that is located within the reactor pressure boundary in a concentric arrangement. Clean water from the annulus outside the liner is continually flowed through the liner creating a boundary layer of clean water on its inner surface. This layer of water protects the liner surface from contact with reaction products thus preventing acid attack and salt deposition. Foster Wheeler constructed a transpiring wall SCWO unit under a contract for the U.S. Navy and demonstrated destruction of total organic carbon in shipboard excess hazardous materials to 99.99 percent Destruction and Removal Efficiency. The unit was tested for approximately 71 hours with feed material containing chlorides and fluorides. The unit operated without concern for corrosion and plugging.

Under the Assembled Chemical Weapons Assessment (ACWA) program, the Army has evaluated alternative technologies to chemical weapon incineration for destruction of chemical weapons located at Blue Grass Army Depot in Kentucky. The transpiring wall SCWO system is a key element in a total solution for destruction of these chemical weapons that involves weapon disassembly and caustic hydrolysis of contained chemical agent and energetic materials. Although the resulting hydrolysate is free of agent and energetic materials, it contains Schedule 2 compounds and other organic materials that require elimination using SCWO. Under an Army contract, Foster Wheeler modified the Navy SCWO unit and then moved and installed it at Army's Dugway Proving Ground facility in Utah.

The technology demonstration/validation required performance of SCWO tests with feed materials derived from caustic hydrolysis of chemical agents VX, GB and HD and energetic materials. In some cases, simulants of hydrolysates were used. A total of 231 hours of validation testing was performed between July and September 2000. The testing validated destruction of Schedule 2 compounds to acceptable levels. Unit operability with regard to reactor corrosion and plugging for the feed hydrolysates containing corrosive species such as chlorine, fluorine, phosphorous, and sulfur and large quantities of inorganic salts was demonstrated. In some cases these feed hydrolysates contained inorganic salts of aluminum. A complete characterization of solid, liquid and gaseous effluents was performed.

This briefing describes the transpiring wall reactor and presents results of the Navy and ACWA demonstration testing, particularly with regard to corrosion and salt plugging.

Application of TW-SCWO Reactor for Destruction of Shipboard Wastes and Chemical Weapons

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Supercritical Water Oxidation - Achievements & Challenges in Commercial Applications
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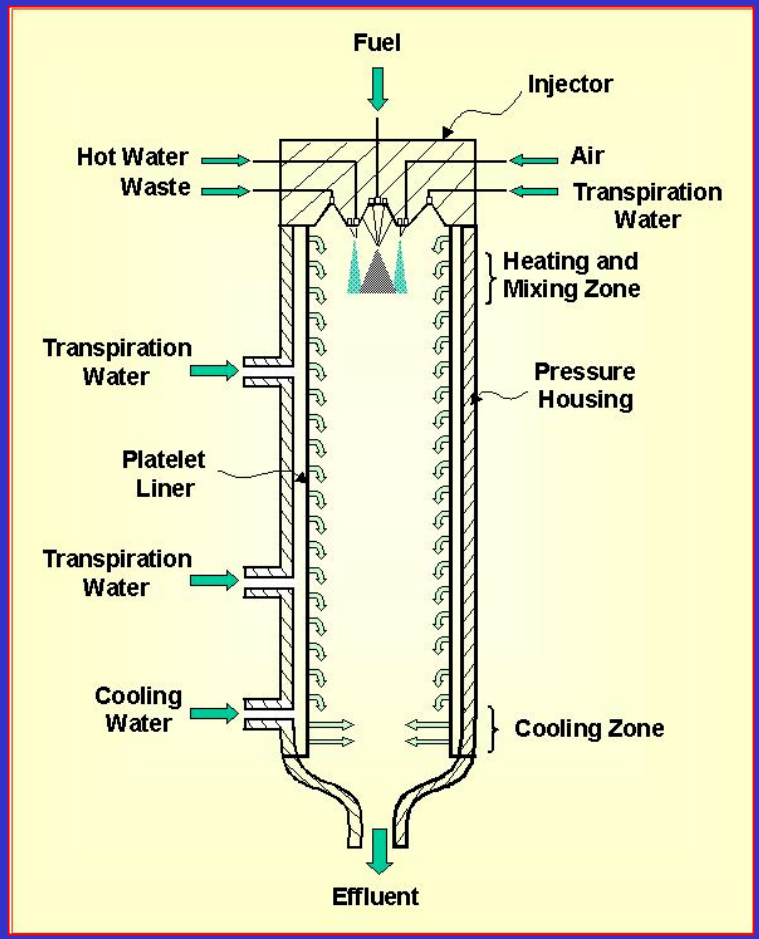
Test Programs

- Testing to Demonstrate Application of TW-SCWO Technology for Destruction of Shipboard Hazardous Materials Under a Contract from the Office of Naval Research

- Testing to validate TW-SCWO Technology for Destruction of Hydrolysates of Chemical Agents and Energetic Materials Under Army's Assembled Chemical Weapons Assessment (ACWA) Program

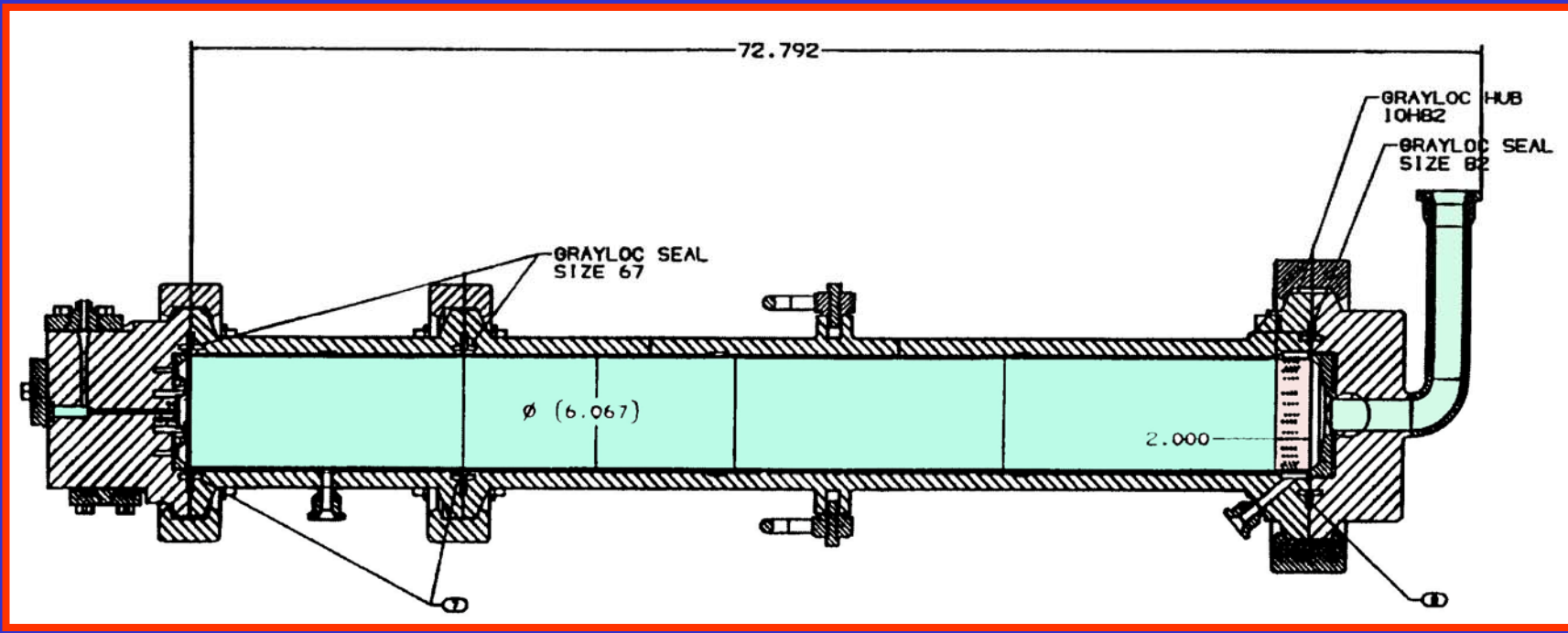
Transpiring Wall SCWO Reactor



Reactor Features:

- Protection against salt deposition and corrosion
- Liner isolates pressure vessel from reaction: enhanced safety and longer life
- High temperature operation; shorter reactor and high destruction efficiency

Supercritical Water Oxidation Reactor



Design Basis Shipboard Hazardous Materials

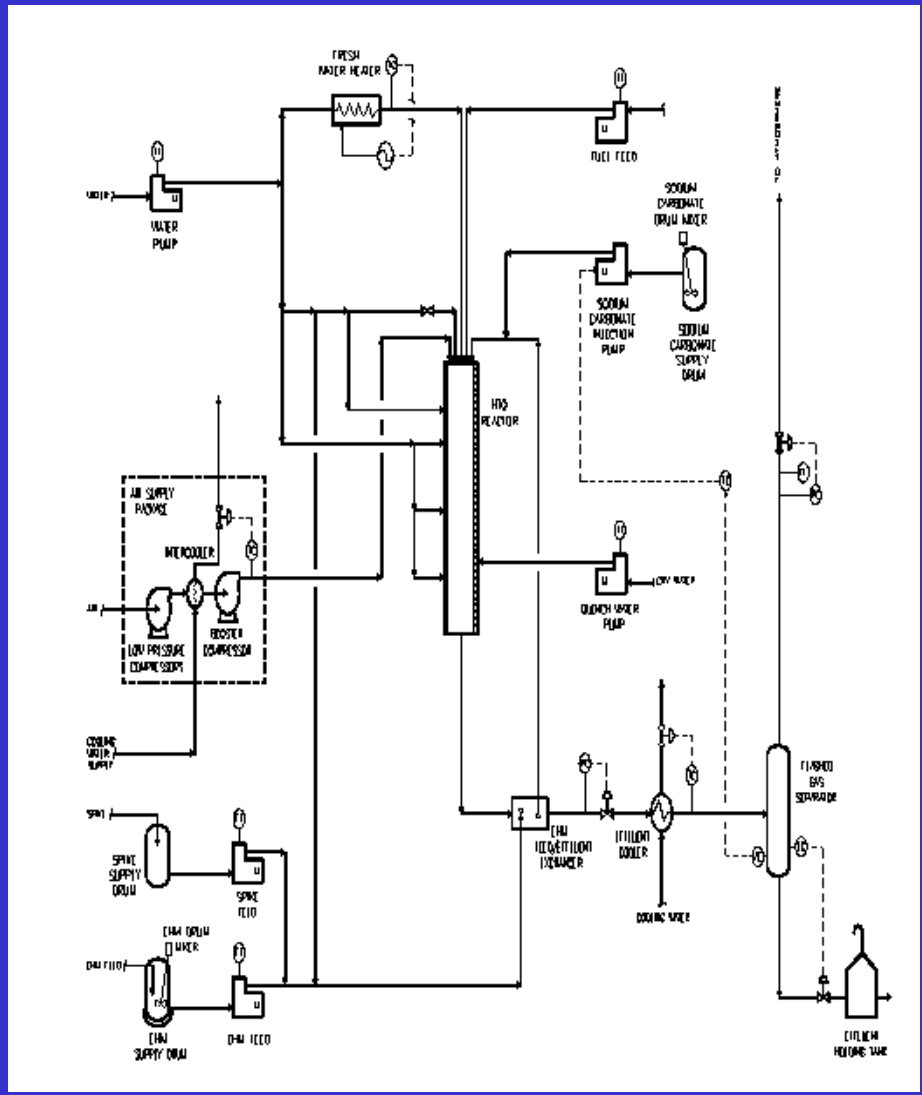
No.	Selection Criteria	EHM Surrogate
1	Max. Btu with max. zinc content	Lube oil with zinc organophosphate
2	Max. Btu with max. phosphorus contaminant	Hydraulic fluid
3	Max. sulfur content	Moly. Disulfide lube oil (10%) plus diluent* (90%)
4	Max. flourine content	Polychlorotrifluoroethylene (1%) plus diluent* (99%)
5	Max. chlorine content	Trichloroethane (10%) plus diluent* (90%)
6	Max. solids content	Blended paint
7	Max. salts content	Mixed photographic solution (simulant)
8	Max. antioxidant content	Glycol with antioxidant
9	Minimum Btu	Gray water at 0.5 wt% concentration
10	Minimum Btu	Black water at 0.5 wt% concentration

*Diluent is JP-5 or kerosene

Design Guidelines for Shipboard SCWO Unit

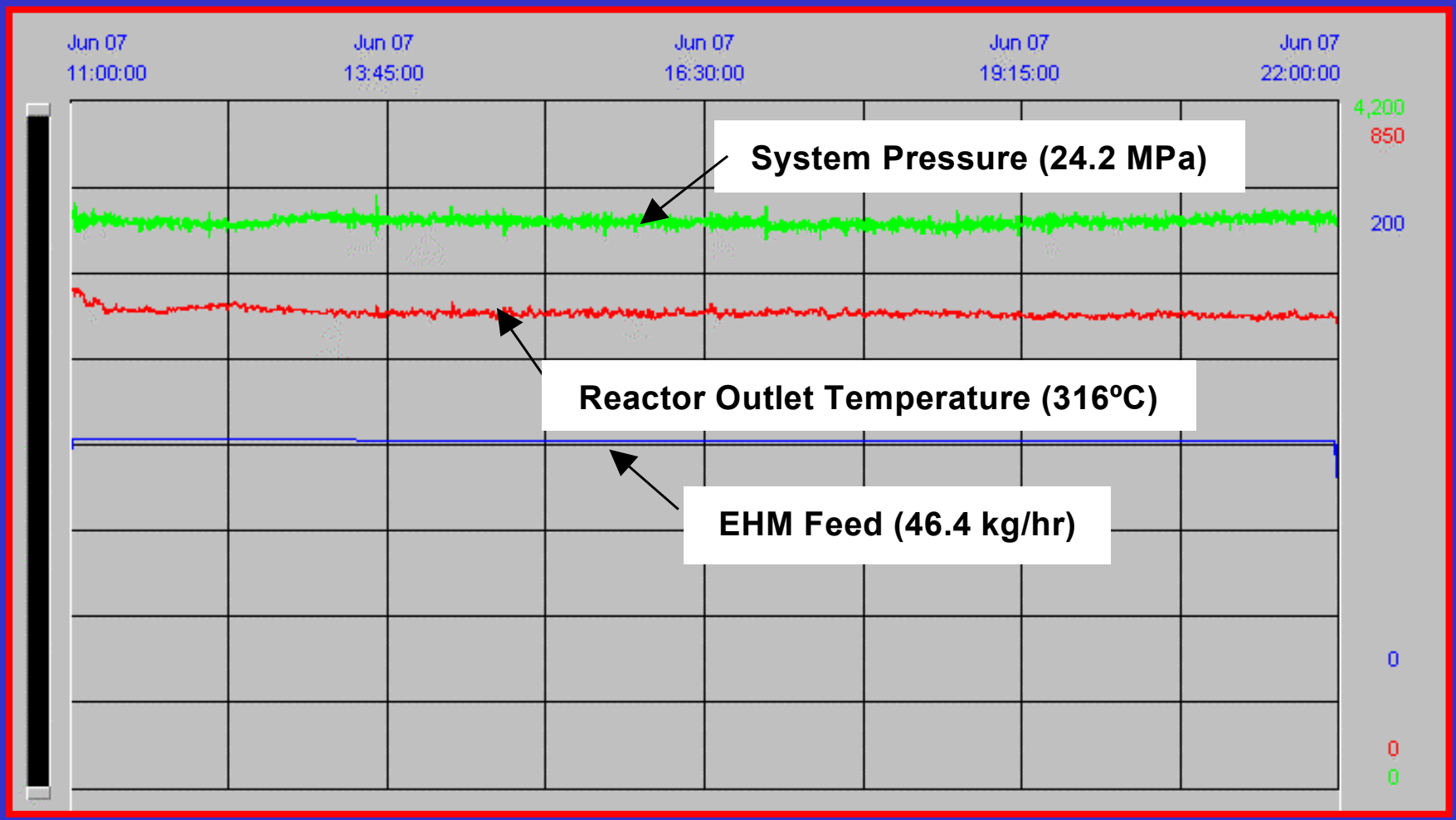
- 10 hr/day continuous processing capability of 45.4 kg/hr
- Minimize weight and size
- Destruction removal efficiency (DRE) of 99.99%
- Automatic operation
- Safe and reliable operation (plugging, corrosion)
- High maintainability
- Compatibility with shipboard operations

Shipboard SCWO Demonstration Unit PFD



Shipboard SCWO Demonstration Unit

Shipboard SCWO Test - TCA/Kerosene



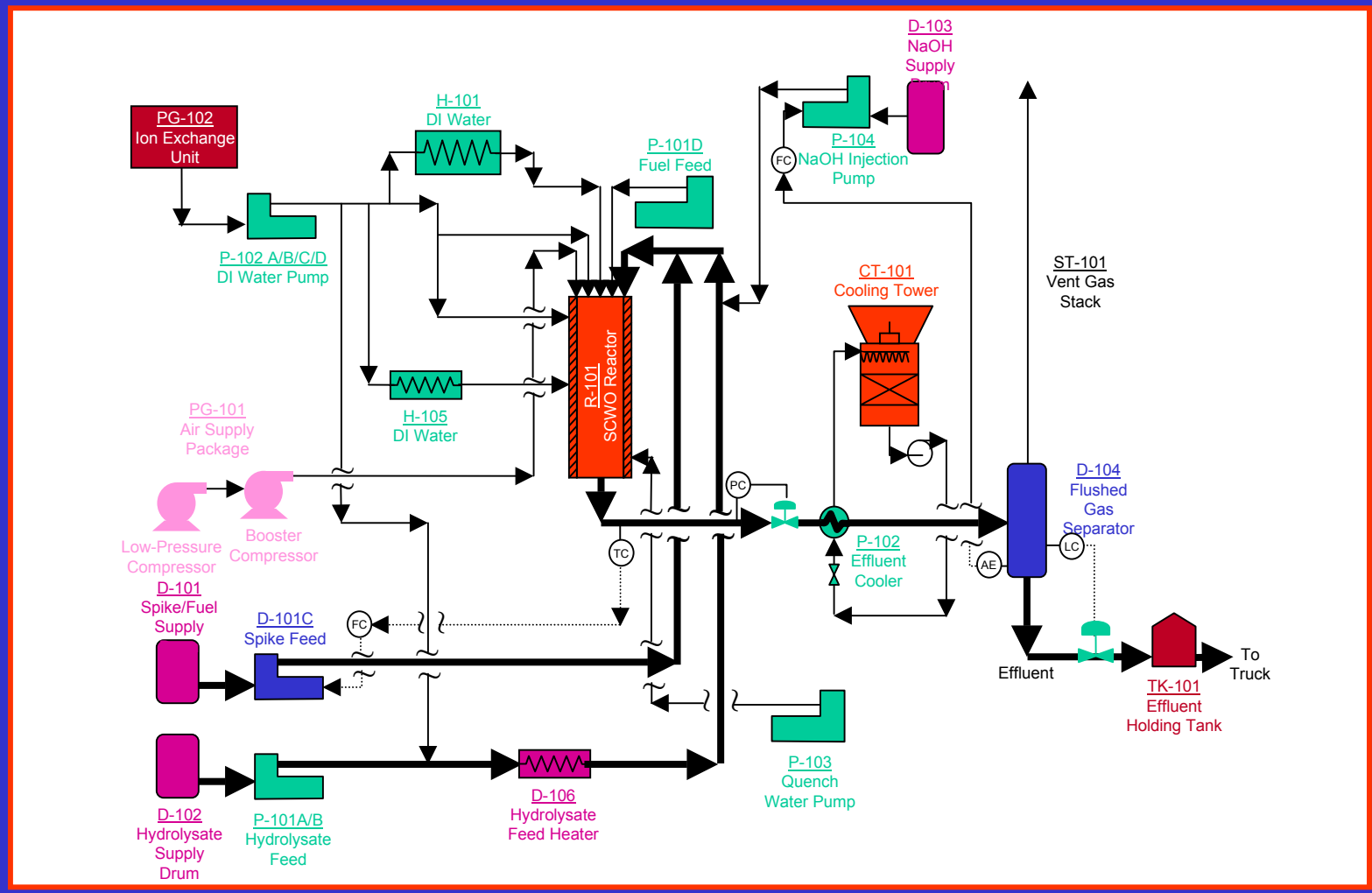
Shipboard Hazardous Material SCWO Destruction Test Results

Feed	Hours	Feed Rate (kg/hr)	Pressure (MPa)	Outlet Temp (deg C)	DRE (%)	TOC (ppm)	Operation
Kerosene	n/a	36.3	24.0	307	>99.98	2.8	Without
PCTFE	23	36.3	24.0	310	>99.99	1.4	Plugging
TCA	32	46.4	24.2	316	>99.99	3.3	or
Photo	16	46.9	25.0	307	>99.99	1.3	Corrosion

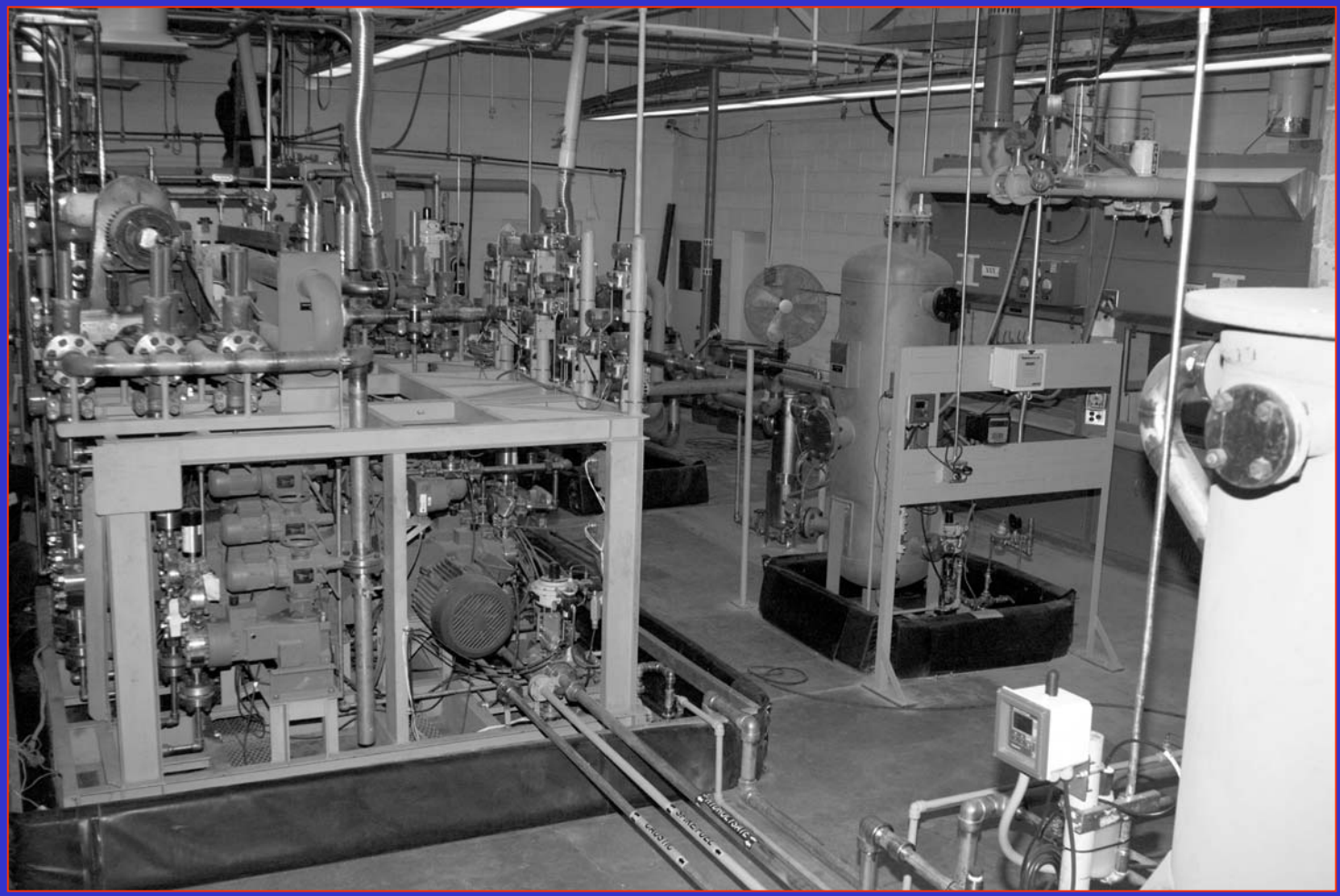
ACWA SCWO Demo II Test Objectives

- Demonstrate long-term, continuous operability of SCWO with respect to:
  - Salt plugging
  - Corrosion
  - Effect of operation on the platelet liner
  - Erosion of the pressure control valve
- Determine if aluminum from the Energetics Hydrolysis process can be processed by SCWO without plugging
- Validate the ability of SCWO to eliminate Schedule 2 compounds
- Characterize the gas, liquid and solid process streams

ACWA SCWO Process Flow Diagram



SCWO Unit at Dugway Proving Ground



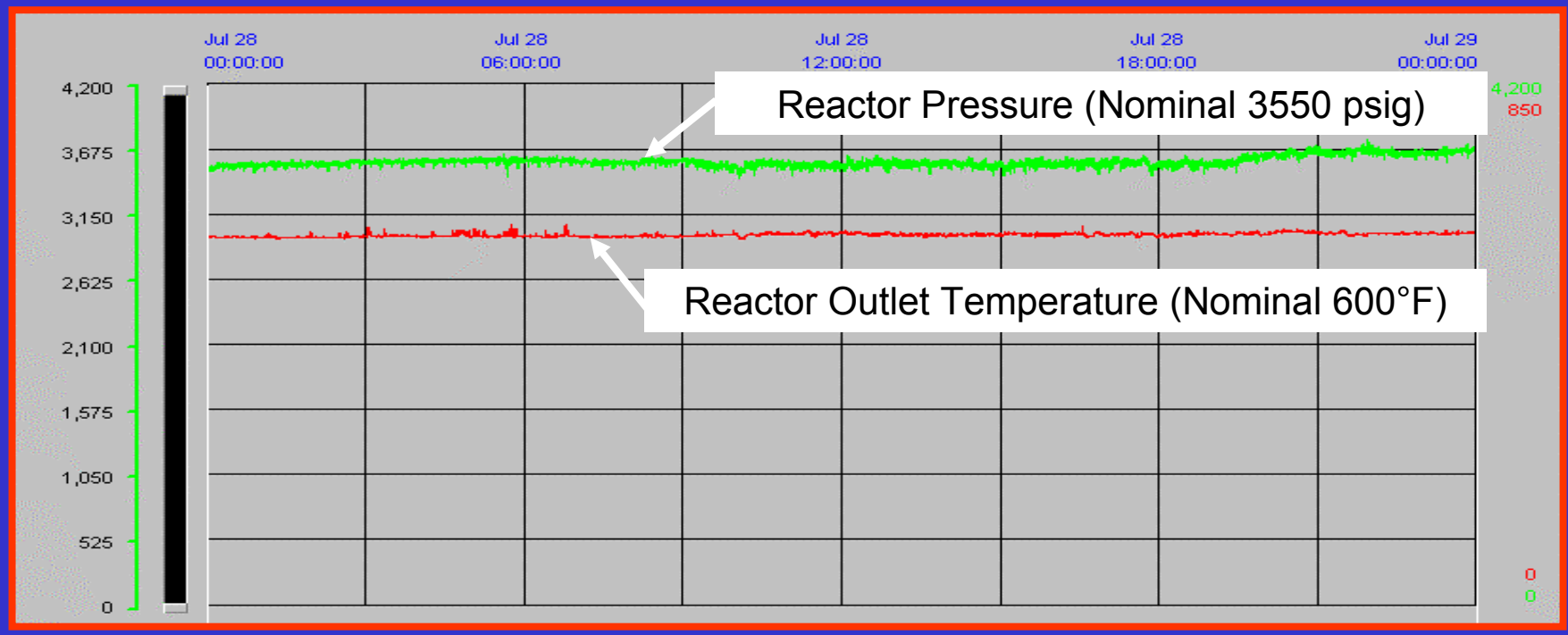
ACWA SCWO Demo II Test Matrix

FEED	PLANNED		ACTUAL	
	Quantity per Validation Run	# of Validation Runs (Duration)	Quantity per Validation Run	# of Validation Runs (Duration)
Agent & Energetic Hydrolysates				
VX Simulant	6,000 lbs	1 (100 hrs)	6,000 lbs	1 (100 hrs)
HD/Tetrytol/Aluminum Hydrolysate	6,000 lbs	1 (100 hrs)	3,300 lbs	1 (55 hrs)
GB/Comp B/Aluminum Hydrolysate	6,000 lbs	1 (100 hrs)	3,000 lbs	1 (50 hrs)
VX/Comp B/Aluminum Hydrolysate	6,000 lbs	1 (100 hrs)	1,560 lbs	1 (26 hrs)

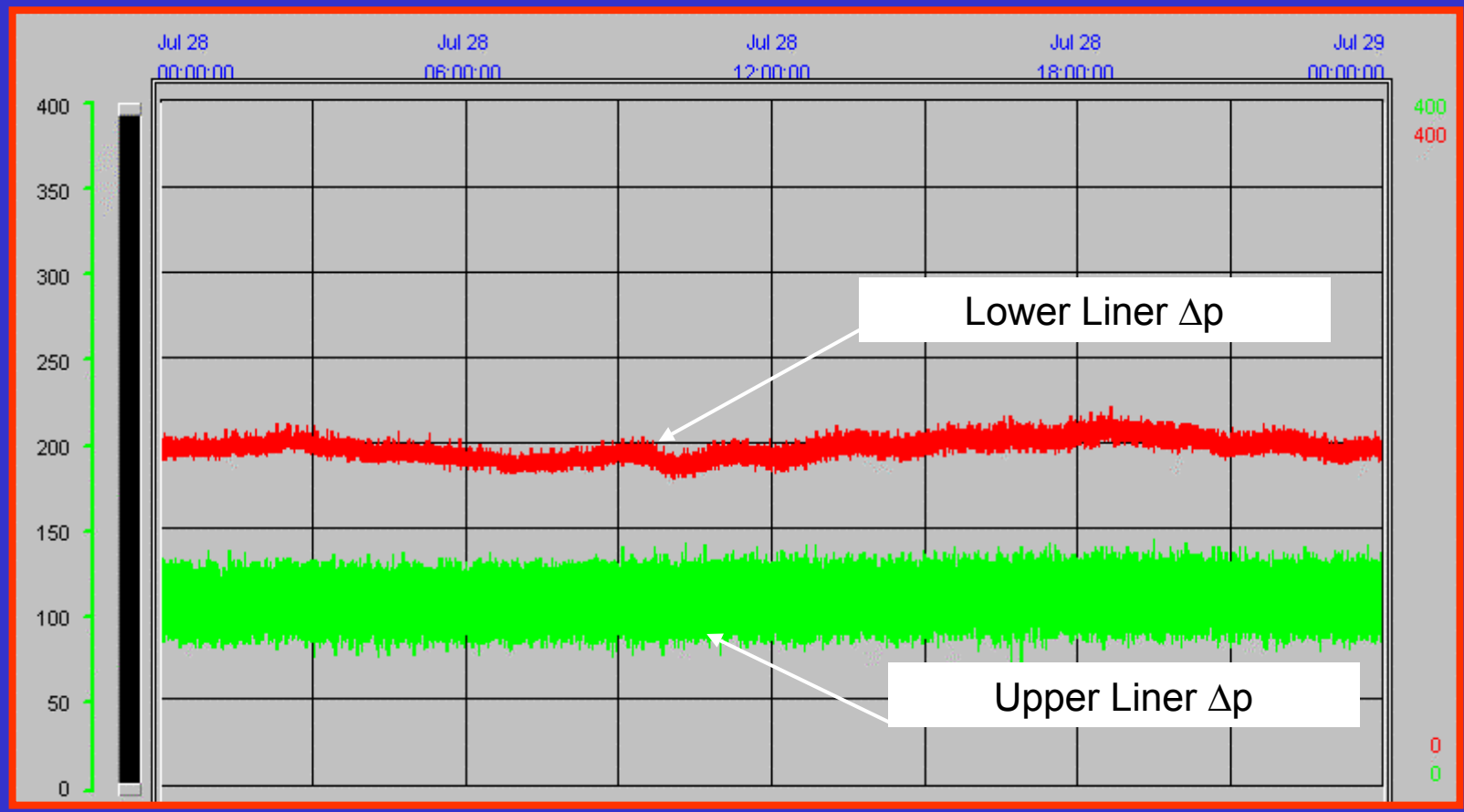
Process Parameters for VX Hydrolysate Simulant Run

Hydrolysate Feed Rate	60-70 LB/hr
Air Flow Rate	1350-1500 LB/hr
System Pressure	3500-3600 psig
Reactor Outlet Temperature	600 F

VX Hydrolysate Simulant Run
Reactor Pressure & Outlet Temperature



Liner Δp During VX Hydrolysate Simulant Run



Reactor Liner After 100-hr VX Hydrolysate Simulant Run

ACWA Validation Testing Long-Term Operability

Plugging and Corrosion/Erosion

- None or minimal plugging and corrosion in TW-SCWO Reactor even with aluminum-rich feeds.
- Downstream low-pressure exchanger plugging for aluminum-rich feeds. *Exchanger has been redesigned for slurry service.*
- Reliable pressure control device identified for all feeds

Liner Integrity/Durability

- One liner cracking incidence due to a fabrication flaw in a liner section. *Improved QA/QC for EDS II reactor fabrication.*
- One local deformation incidence due to use of "wrong" liner. TW Reactor continued to perform with liner deformation.

VX Hydrolysate Simulant 100-run interrupted twice by air compressor trip. ***Air compressor replaced by oxygen at full-scale.***

TW-SCWO Technology Validated for Use in Destruction of Chemical Weapons

ACWA Engineering Design Studies (EDS) (March - November 2001)

- Use of oxygen.
- EDS testing will use new TW-SCWO reactor.
- Alternate pressure control device(s)
- Crystalizer/Evaporator
- Workup tests at up to 300 lb/hr - 133 hrs steady state (*completed - used Navy HTO reactor)*
- 500 hr test runs
  - GB Agent/Sim, Energetics and Aluminum Hydrolysates
  - VX Agent/Sim, Energetics and Aluminum Hydrolysates
  - HD Agent/Sim, Energetics and Aluminum Hydrolysates

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